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This reports covers the **aerosol ocean** and **aerosol land** algorithm, and our involvement in the **NIR water vapor** and fire **algorithms**.

Main topics addressed in this period:

1. Development of new technique for remote sensing of dust in the solar wavelengths *(Kaufman, Tanre, Li, Mattoo.*)
2. Development of new technique for assessing the dust optical properties using a combination of satellite and ground based instruments*(Kaufman, Tanre, Li, Matroo.*)
3. A First Inference of Atmospheric Response to Dust Forcing from a Data Assimilation System, paper accepted in Nature.
4. Field experiment to characterize smoke due to El Niño enhanced biomass burning events in Mexico and Florida (*Remer, Kleidman*)
5. Validation of retrieved aerosol optical thickness and total precipitable water from AVIRIS images with sunphotometer observations (*Chu, Kaufman*)
6. Study of spectral dependence of single scattering albedo in visible wavelength (*Chu, Kaufman*)
7. Test of V2 PGE04 code to comply updated library software on SCF and implementation of mandatory DAAC operator action message (*Chu*)
8. Sensitivity study of aerosol retrieval over ocean due to wind speed and ozone absorption (*Mattoo,Kaufman,Tanre)*
9. Test of cloud mask on TARFOX MAS data (*Mattoo, Li*)
10. Test of cirrus correction algorithm using AVIRIS data over land and ocean (*Li,Kaufman, with lead from Gao)*
11. Ground spectral measurements for vegetation and soil surfaces (*Wald*)
12. Validation of dust IR algorithm over desert using AVHRR images (*Wald*)
13. Test of new device to calculate cloud fraction with temporal match with sunphotometer observations - a summer student project (*Remer, Wald*)
14. Acquisition of TM images for Asian dust event off southern California coast and for dust storm in west Africa coast this spring (*Remer, Fraser*)

Topics postponed (or continued) to next quarter

1. Submission of updated aerosol ATBD

1. Development of new technique for remote sensing of dust in the solar wavelengths

While remote sensing of dust over the dark oceans is feasible, adequate techniques for remote sensing over the land still have to be developed. Here, similar to remote sensing of aerosol over vegetated regions, we use a combination of visible and mid-IR solar channels to detect dust over the desert. Why is it possible? Dust has a smaller effect on radiation at 2.1 μm then in the red and blue parts of the spectrum. The bright desert reflectance at 2.1 μm and small dust absorption of direct and reflected sunlight, decreases the dust effect further. Thus the desert reflectance at 2.1 μm can be observed through the dust and used to estimate the desert reflectance in the visible channels. Similar to vegetated surfaces we found that desert reflectance in the visible channels is highly correlated with the reflectance at 2.1 μm. The difference between the estimated reflectance in the visible channels and the apparent reflectance measured from space is used to derive the dust opacity. Analysis of Landsat TM data over Senegal for images taken in 1986 and 1987 shows that the surface reflectance at 0.64 μm ($\rho_{0.64}$) is between 0.51 and 0.57 of the reflectance at 2.1 ($\rho_{2.1}$) with variation of ±0.05. The reflectance at 0.47 μm is between 0.23 and 0.30 of $\rho_{2.1}$ with variation of ±0.03, surprisingly similar to relationships in non desert sites. Application to Landsat images of heavy dust taken during sunphotometer observations shows that the dust optical thickness, τ, can be derived within $\Delta\tau=\pm0.5$ for the range of 0-2.5, thus enabling rough remote sensing estimate of dust over the desert. The method is very sensitive to the correct knowledge of the dust absorption, and is equally sensitive to dust in the entire atmospheric column. It is best applied in the red part of the spectrum (around 0.64 μm) where dust (at least from the Saharan belt) is essentially nonabsorbing. We plan to use as part of the dust monitoring from the Earth observing System MODIS instrument. A paper is in preparation.

2. Development of new technique for assessing the dust optical properties using a combination of satellite and ground based instruments

Spectral remote observations of dust properties simultaneously from space and from the ground creates a powerful tool for the determination of the properties of ambient dust in the entire atmospheric column. Such measurements, of direct relevance to dust forcing of climate, will be readily available soon with the launch in 1999 of the MODIS instrument on the Earth Observing System and the AErosol RObotic NETwork (AERONET) of ground based sun/sky radiometers. Here using the spectral measurements (0.47 to 2.21 μm) from Landsat TM over Senegalian coast and AERONET radiances measured at Cap Verde and Sede Boker (on both sides of the Sahara) we derive the dust properties. The observations introduce a cascade of increasing dependence on dust properties that are derived sequentially: (i) the dust size distribution is derived from the AERONET sky aureole; (ii) Landsat TM data

over the land using the balance between dust scattering and absorption of light reflected by the bright surface, derive the dust spectral imaginary index of refraction; (iii) Landsat TM data over the ocean at 148° scattering angle serve as a closure to the dust properties and bound the real part of the refractive index; (iv) AERONET sky radiance at scattering angle of 120°, add information on the dust nonsphericity effect on the scattering phase function. Dust is found to be dominated by particles with effective radius around 2 μm, real refractive index ~ 1.5, single scattering albedo of ω_0=0.88 at 0.47 μm, (n_i=-0.003) and $\omega_0 \geq$ 0.97 for 0.55 μm ≤ λ (-0.001 ≤ n_i). The particle nonsphericity increases the phase function at 120° by 30 to 50% at 0.67 μm and 0 to 15% at 1 μm for Cap Verde and Sede Boker respectively. The significantly lower dust absorption changes the dust net forcing at top of atmosphere from close to zero in the models to negative and reduces by a factor of 3 the solar heating of the lower troposphere. A paper is in preparation.

3. A First Inference of Atmospheric Response to Dust Forcing from a Data Assimilation System, paper accepted in Nature.

In a data assimilation system, observational data is used to correct a short term forecast or first guess. These corrections provide information about missing physical processes not included in the predictive model, e.g. the radiative forcing of dust and other aerosols. A striking similarity is shown between monthly patterns of dust over the Atlantic, detected independently from satellite, and the corrections or updates generated during the course of an assimilation employing the NASA Goddard Earth Observing System (GEOS) Data Assimilation System. A high correlations is observed between latitudinal location of maximum heating in atmospheric modeling updates and that of the number of dusty days. This enables us for the first time to calculate from assimilated observations the atmospheric response to dust aerosols resulting in an average heating of 6K/yr within the Saharan dust layer at 1.5-3 kms. This atmospheric response to dust is in bulk agreement with theoretical predictions, e.g. the Carlson and Tegen models.

4. Field experiment of characterization of smoke due to El Niño enhanced biomass burning events in Mexico and Central America

Organized and participated in spontaneous field experiment to characterize smoke of El Niño enhanced biomass burning events in Mexican and Central America. Coordinated and performed ground measurements with TM overpasses along Gulf Coast states of US. Coordinated in-situ measurements from NCAR aircraft at three ground-sites in Mexico. Processed data show consistency at all observation locations but different from similar measurements made in Brazil, Africa and Indonesia. A follow-up ground observations of smoke resulting from forest fire in Florida is also performed.

5. Validation of retrieved aerosol optical thickness and total precipitable water from AVIRIS images with sunphotometer observations

Performed the validation of aerosol optical thickness and total precipitable water retrieved from AVIRIS data against sunphotometer measurements. Good agreement is found for total precipitable water derived from AVIRIS data. The aerosol results show large sensitivity to single scattering albedo at both 0.47 and 0.67 μm. Especially over red soil in Cuiaba, underestimation of aerosol optical thickness is found due to the uncertainties in surface reflectance.

6. Study of spectral dependence of single scattering albedo in visible wavelength

The large sensitivity of aerosol optical thickness to single scattering albedo results in the value of single scattering albedo equal to 0.88 and 0.91 at 0.47 and 0.67 μm, respectively, for the best fit of aerosol optical thickness to sunphotometer measurements. Plan is taken to extend to 0.55 μm wavelength.

7. Test of V2 PGE04 code to comply updated library software on SCF and implementation of mandatory DAAC operator action messages

The V2 PGE04 code (aerosol and total precipitable water) was tested on SCF with updated library software and with the mandatory DAAC operator action implementation.

8. Sensitivity study of aerosol retrieval over ocean due to wind speed and ozone absorption

The analysis of aerosol properties retrieved from TARFOX MAS images was finished with additional sensitivity test on wind speed and ozone correction. A paper titled “Retrieval of aerosol optical thickness and size distribution over ocean from MODIS Airborne Simulator during TARFOX” is nearly ready to submit to JGR TARFOX special issue part II.

9. Test of cloud mask on TARFOX MAS data

A thorough test of cloud mask on TARFOX MAS data has begun with special emphasis on cloud, glint, land / sea, shadow, cirrus cloud, and non-cloud obstruction flags. The summary of the test will be reported to MODIS cloud mask team at University of Wisconsin for further improvement of the cloud mask.

10. Test of cirrus correction algorithm using AVIRIS data over land and ocean

Collected thirty-seven AVIRIS images with cirrus cloud. Two cases (one over land and one over ocean) have been analyzed with promising outcome. A detailed validation with and without cirrus cloud at the same location is planned.

11. Ground spectral measurements for vegetation and soil surfaces

The scaled-down second ground measurements of land surface in Israel took place in May 25 - June 8, with special focus on the desert transition region. The purpose of this field trip is to make measurements of vegetation and soils from visible to infrared spectrum for use in retrieval of aerosols over continents and in spectral mixing models.

12. Validation of dust IR algorithm over desert using AVHRR images

The validation of dust IR algorithm over desert using AVHRR images has started. HIRS dust retrievals over land near coastlines will also be compared with AVHRR retrievals of aerosol over nearby ocean. Several appropriate AVHRR images of the west coast of Africa have been obtained.

13. Test of new device to calculate cloud fraction with temporal match with sunphotometer observations - a summer student project

The combination of a digital camera with a red filter and a spherical mirror is used to calculate the cloud fraction with closely temporal match with sunphotometer observations. The mirror distortion will be accounted. The cloud fraction data collected throughout this summer, along with water vapor and aerosol optical thickness, will be used to study the interaction between cloud and aerosol.

14. Acquisition of TM images for dust and smoke events

Information of TM images was collected for acquisition of TM images for the study of Asian dust off southern California coast, for dust storm in west Africa coast, and for smoke events in New Orleans as a result of El Ninõ enhanced forest fires in Mexico and Central America this spring. The TM images will be used to test the MODIS aerosol algorithm.

Paper acceptance to JGR SCAR-B special issue

1. **Wald** A. E., Y. J. Kaufman, D. Tanre, and B.-C. Gao, Daytime and nighttime detection of mineral dust over desert using infrared spectral contrast, JGR, SCAR-B special issue.
2. **Chu**, D. A., Y. J. Kaufman, L. A. Remer, and B. N. Holben, Remote sensing of smoke from MODIS Airborne Simulator during SCAR-B experiment, JGR, SCAR-B special issue.
3. "Tropical Biomass Burning Smoke Aerosol Size Distribution Model", L. A. **Remer**, Y.J. Kaufman, B.N. Holben, A.M. Thompson and D. McNamara, accepted to JGR special issue on SCAR-B, 1998
4. "The Smoke, Clouds and Radiation Experiment in Brazil (SCAR-B)", Y. J. **Kaufman**, P. V. Hobbs, V. W. J. H. Kirchhoff, P. Artaxo, L. A. Remer, B. N. Holben, M. D. King, E. M. Prins, D.E. Ward, K. M. Longo, L. F. Mattos, C.A. Nobre, JK.D. Spinhirne, Q. Ji, A. M. Thompson, J. F. Gleason, S. A. Christopher, and S.-C. Tsay, accepted for JGR special issue on SCAR-B, 1998.
5. O. **Dubovik**, B.N. Holben, Y. Kaufman, M. Yamasoe, A. Smirnov, D. Tanre, I. Slutsker, "Single-scattering albedo retrieval from the sky-radiance measured by ground based sun-photometer", submitted to J. Geophys. Res. special issue on SCAR-B, 1998.

Other accepted papers:

1. A First Inference of Atmospheric Response to Dust Forcing from a Data Assimilation System, P. **Alpert**, Y. J. Kaufman, Y. Shay-El, D. Tanre, A. da Silva, S. Schubert, Y. H. Joseph, accepted to Nature, 1998
2. "Monitoring Global Fires from EOS-MODIS", Y. J. **Kaufman**, C. Justice, L. Flynn, J. Kandall, E. Prins, D. E. Ward, P. Menzel and A. Setzer accepted to JGR special issue on EOS, 1998.
3. "Correction of thin cirrus path in the 0.4-1.0 µm spectral region using the sensitive 1.375 µm cirrus detection channel.", B.-C. **Gao**, Y.J. Kaufman, W. Han and W.J. Wiscombe. submitted to JGR special issue on EOS, 1998.
4. "Model for Urban industrial aerosol", L.A. **Remer** and Y.J. Kaufman accepted to JGR, 1998

Meeting attended

1. MODIS 1-on-1 meeting with ECS and GDAAC May 19 *(Chu*)
2. MODIS science team meeting June 24-26 (*Kaufman, Remer, Gao, Chu, Mattoo, Li*)
3. SAFARI 2000 planning meeting June 29-30 (*Kaufman, Remer*)